RECOMMENDATION ITU-R S.1560

Methodology for the calculation of the worst-case interference levels from a particular type of non-geostationary fixed-satellite service system using highly-elliptical orbits into geostationary fixed-satellite service satellite networks operating in the 4/6 GHz frequency bands

(Question ITU-R 236/4)

(2002)

The ITU Radiocommunication Assembly,

considering

a) that many fixed-satellite service (FSS) frequency bands, including the 4/6 GHz bands, may be used for both geostationary (GSO) satellite networks and non-GSO satellite systems in accordance with the Radio Regulations (RR);

b) in the 4/6 GHz bands non-GSO systems shall not cause unacceptable interference to GSO FSS networks in accordance with the provisions of RR No. 22.2;

c) that administrations may need to calculate the worst-case interference level that is generated from a non-GSO system into any GSO network in the 4/6 GHz frequency bands;

d) that the 4/6 GHz FSS frequency bands are heavily used by existing and planned GSO FSS networks,

noting

a) that information relating to non-GSO systems using highly-elliptical orbits in the FSS in frequency bands below 10 GHz has been received by the Radiocommunication Bureau;

b) that RR No. 22.2 is an operational provision which is to be applied between administrations, and it is up to the affected GSO FSS administration to determine whether a non-GSO FSS system is causing unacceptable interference to a GSO FSS network;

c) that the types of highly-elliptical orbit non-GSO FSS systems referenced in *noting* a) are characterized by the use of limited operational or “active” arcs that are spatially separated from the GSO as seen from the earth station,

recommends

1 that the worst-case interference level, from a non-GSO FSS system of a type described in the *notings* above using highly-elliptical orbits into a GSO FSS network, be calculated by considering that all co-frequency non-GSO satellites from such a system that are transmitting towards the same geographic region of the Earth are producing their maximum power flux-density (pfd) levels;

2 that for non-GSO FSS systems operating in highly-elliptical orbits in the 4/6 GHz frequency bands, the methodology in Annex 1 to this Recommendation should be used for the calculation of the worst-case levels of interference into GSO FSS networks from non-GSO FSS systems where no transmissions to or from any non-GSO satellite are made within 40° of the GSO as viewed from any point on the Earth's surface;

3 that this methodology may be used by administrations in assessing whether a non-GSO FSS system of a type described in the *notings* above would cause unacceptable interference to a GSO FSS network.

NOTE 1 – Annex 2 gives an example of the use of the methodology of this Recommendation for a non-GSO FSS system of a type described in the *notings* above operating in sub-synchronous inclined elliptical orbits.

NOTE 2 – Further work is required to assess the aggregate interference from such non-GSO systems into GSO networks.

NOTE 3 – The methodology uses worst-case assumptions that overestimate the actual levels of interference. More refined analysis techniques could be used to assess the interference profiles in more detail.

NOTE 4 – The inclination of the GSO satellite should be taken into account in the methodology of Annex 1.

ANNEX 1

Methodology for the calculation of the worst-case interference levels from a particular type of non-GSO FSS system using highly-elliptical orbits into GSO FSS networks operating in the 4/6 GHz frequency bands

The following methodology should be used for the calculation of the potential levels of interference into GSO networks operating in the 4/6 GHz frequency bands resulting from the co-frequency operation of particular types of non-GSO FSS system.

The calculation methodology described in this Annex could overestimate the actual levels of interference. In particular, for the downlink interference assessment, it is assumed that each of the transmitting non-GSO FSS satellites is located at the minimum angular separation from the line-of-sight (LoS) between the GSO earth station and its associated GSO satellite. In a realistic situation, if one of the non-GSO satellites is located at this minimum angular separation, the other non-GSO satellites will be located at some larger angular separation and the interference contributions from these other satellites will be lower. Hence, the overall calculated $\Delta T/T$ degradation would be less than those calculated using this methodology. For both the uplink and the downlink interference assessments, the number of transmitting satellites or earth stations used in this analysis of maximum interference is at the time when a handoff is occurring. This handoff will only occur for short periods of time (generally, about 0.1%) and will result in an overestimation of the maximum interference that would occur for the majority of the time. More refined analysis techniques could be used to assess the interference profiles in more detail.

1 Data concerning the non-GSO system

The following information is required concerning the non-GSO system:

1.1 Space-to-Earth transmissions

$\theta_{D\text{-}min}$:	Minimum angular separation of the active transmitting non-GSO satellites from the LoS between the GSO earth station and its associated GSO satellite (degrees).
$pfd_{D\text{-}non\text{-}GSO\text{-}max}$:	Maximum pfd at the Earth's surface caused by transmissions from each non-GSO satellite in the constellation (dB(W/(m^2 · 1 Hz))).
N_D:	Maximum number of co-frequency non-GSO satellites transmitting towards the same geographic region of the Earth, as well as an indication of the number of such satellites as a function of the percentage of time.

1.2 Earth-to-space transmissions

$\theta_{U\text{-}min}$:	Minimum angular separation of the GSO from the LoS between the transmitting non-GSO earth station and its associated non-GSO satellite (degrees).
$e.i.r.p._{non\text{-}GSO\text{-}max}$:	Maximum off-axis equivalent isotropically radiaded power (e.i.r.p.) spectral density from the transmitting non-GSO earth station corresponding to the minimum angular separation, $\theta_{U\text{-}min}$ (dB(W/Hz)).
N_U:	Maximum number of co-frequency transmitting non-GSO earth stations within a geographic region of the Earth that is likely to be received by a single GSO satellite receive beam.

2 Data concerning the GSO network

The following information is required concerning the GSO network:

2.1 Receive earth station sensitivity

$G_{GSO\text{-}ES\text{-}max}$:	Assumed maximum off-axis gain of the GSO receive earth station in a direction corresponding to the minimum angular separation, $\theta_{D\text{-}min}$, of the non-GSO satellite when it is actively transmitting (dBi). Recommendation ITU-R S.465 provides guidance in this respect.
$T_{GSO\text{-}ES}$:	Assumed clear-sky receive system noise temperature (including receive antenna noise) of the GSO downlink. To err on the conservative side this need not include degradations caused to the overall link resulting from the uplink (K).

2.2 Satellite receive sensitivity

$G_{GSO\text{-}SS\text{-}max}$:	Assumed maximum GSO satellite receive antenna gain (dBi).
$T_{GSO\text{-}SS}$:	Assumed clear-sky receive system noise temperature of the GSO uplink. To err on the conservative side this need not include the overall link including downlink (K).

3 Calculation of downlink interference into the GSO network

The following three Steps are performed to calculate the degradation to the GSO network downlink receive system noise temperature from one non-GSO satellite system:

Step D1: calculate the maximum interfering signal power spectral density (PSD), $I_{0\text{-}ES}$, from a single non-GSO satellite at the GSO earth station antenna output:

$$I_{0\text{-}ES} = pfd_{D\text{-}non\text{-}GSO\text{-}max} + G_{GSO\text{-}ES\text{-}max} + 10 \log \left(\frac{\lambda^2}{4\pi} \right) \qquad \text{dB(W/Hz)} \qquad (1)$$

where λ is the wavelength.

Step D2: calculate the noise PSD, N_0, at the GSO earth station antenna output:

$$N_{0\text{-}ES} = 10 \log (k\, T_{GSO\text{-}ES}) \qquad \text{dB(W/Hz)} \qquad (2)$$

where *k* is Boltzmann's constant.

Step D3: calculate the degradation to downlink receive system noise temperature ($\Delta T/T_D$) from the constellation of non-GSO satellites:

$$\Delta T/T_D = N_D\, 10^{\left(\frac{I_{0\text{-}ES} - N_{0\text{-}ES}}{10} \right)} \qquad (3)$$

4 Calculation of uplink interference into the GSO network

The following four Steps are performed to calculate the degradation to the GSO network uplink receive system noise temperature from one non-GSO satellite system:

Step U1: calculate the maximum pfd spectral density at the GSO space station ($pfd_{U\text{-}non\text{-}GSO\text{-}max}$) from a single non-GSO transmitting earth station. Note that this equation assumes that the non-GSO transmitting earth station is located at the minimum distance from a GSO satellite. It should be noted that at this earth station location, the resultant separation angle will be greater than the minimum separation angle that is used in the analysis. However, since even the minimum separation angle will be greater than 40°, the reduction in the side lobe gain of the non-GSO earth station's antenna is unlikely to fully compensate for reduction in interference path loss. Thus, this will probably overestimate the interference that is received.

$$pfd_{U\text{-}non\text{-}GSO\text{-}max} = e.i.r.p._{non\text{-}GSO\text{-}max} - 10 \log \left(4\pi (35\,786)^2 \right) \qquad (4)$$

Step U2: calculate the interfering signal PSD, $I_{0\text{-}SS}$, at the GSO space station antenna output:

$$I_{0\text{-}SS} = pfd_{U\text{-}non\ GSO\text{-}max} + G_{GSO\text{-}SS\text{-}max} + 10 \log \left(\frac{\lambda^2}{4\pi} \right) \qquad (5)$$

where λ is the wavelength.

Step U3: calculate the noise PSD, N_0, at the GSO space station antenna output:

$$N_{0\text{-}SS} = 10 \log (k\, T_{GSO\text{-}SS}) \qquad \text{dB(W/Hz)} \tag{6}$$

where k is Boltzmann's constant.

Step U4: calculate the degradation to uplink receive system noise temperature, $\Delta T/T_U$:

$$\Delta T/T_U = N_U\, 10^{\left(\frac{I_{0\text{-}SS} - N_{0\text{-}SS}}{10}\right)} \tag{7}$$

5 Multiple non-GSO FSS systems

The above methodology, if applied to the situation where there are multiple non-GSO FSS systems of this particular type operating in the 4/6 GHz frequency bands, would greatly overestimate the actual degradation to the GSO network uplink and downlink receive system noise temperatures from multiple non-GSO satellite systems. This is due to the fact that the minimum angular separation from the GSO arc is assumed for each satellite. In a situation where there are multiple non-GSO systems of this type, the satellites would be distributed throughout each of the active arcs and very few would be at this minimum separation angle. As a result, this approach may be used as a preliminary analysis tool for the case of multiple systems, but more detailed analysis that takes into account the locations of the satellites of each system in the active arcs would be necessary to evaluate the impact of the aggregate interference from multiple systems.

ANNEX 2

Example of the application of the methodology in this Recommendation to the calculation of the worst-case interference levels from a particular type of non-GSO FSS system operating in sub-synchronous inclined highly elliptical orbits into GSO FSS networks in the 4/6 GHz frequency bands

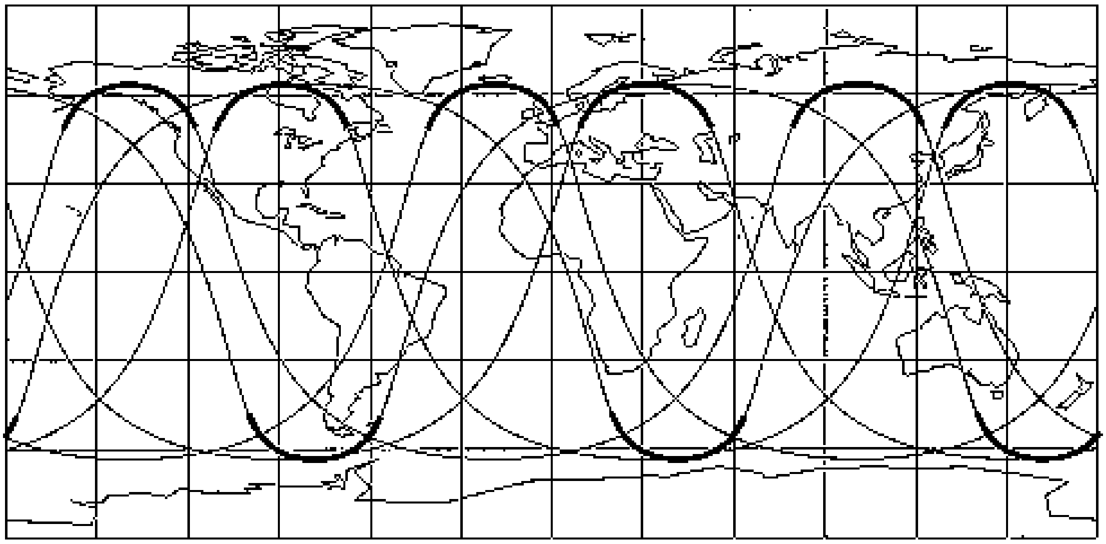
1 Candidate non-GSO system under consideration

The type of non-GSO FSS system considered here proposes to use sub-synchronous inclined elliptical orbits in order to ensure a large angular separation of the active satellites from the GSO orbit. Such a system has been proposed as USAKU-H2 in ITU. This system is a highly-elliptical orbit non-GSO FSS system that uses sub-synchronous inclined elliptical orbits in order to ensure a large angular separation of the active satellites from the GSO orbit. The system would provide FSS to all of the world's populated land masses by means of its user and gateway links. Note that this system proposes to utilize only gateway types of links in the 4/6 GHz frequency bands that are the subject of this Recommendation. Such gateway links would use a relatively small number of large earth stations, which further minimizes any interference to GSO FSS networks. A brief summary description of the system is given below, but more detailed information on this proposed system may be found in Recommendation ITU-R S.1328.

The USAKU-H2 system is comprised of three five-satellite sub-constellations that have repeating ground tracks. Two of the five-satellite sub-constellations follow separate ground tracks in the northern hemisphere, and the third sub-constellation follows a southern hemisphere ground track. The system is designed so that the satellites are active (i.e. transmit or retransmit and receive radiocommunication signals) only when in the portion of the orbit near apogee, where the satellite is travelling at the slowest rate of speed. These active arcs for each sub-constellation occur only when the satellites are at latitudes above 45° N for the northern hemisphere sub-constellations and 45° S for the southern hemisphere sub-constellation. The system design is such that there are three active arcs for each sub-constellation, and that none of the active arcs cross each other. At any point in time for each sub-constellation/ground track, there will be one satellite in each of the three active arcs and two satellites that are not within the active arcs. It should be noted that there are times when there will be two satellites in a given active arc (one at the beginning and one at the end) in order to perform housekeeping and handover activities. This system design results in the active satellites being separated from the GSO LoS by at least 40° at all times. The USAKU-H2 system thus achieves an optimized combination of very high elevation angles, low signal propagation delays compared to GSO satellites, limited satellite handoffs, and high angular separation from the GSO orbit. It also provides non-uniform distribution of capacity to the northern and southern hemispheres in proportion with demand. Fig. 1 shows the sub-satellite ground tracks of the USAKU-H2 system, with the active service arcs indicated by the bold lines.

FIGURE 1

Sub-satellite ground tracks of the USAKU-H2 system



2 Frequency bands

The USAKU-H2 system is proposed to operate its gateway links in the 5 925-6 725 MHz (Earth-to-space) and 3 700-4 200 MHz frequency bands (space-to-Earth). Each USAKU-H2 satellite provides bent-pipe communications channels in these bands between its gateway links in these bands and its user links that operate in other frequency bands.

3 Key parameters for calculation of interference to GSO FSS networks in the 4/6 GHz frequency bands

For the type of non-GSO system considered in this Recommendation the following parameters are necessary for the assessment of interference into co-frequency GSO FSS networks:

3.1 Downlink interference into GSO networks

D1: Minimum angular separation of the active transmitting non-GSO satellites from the LoS between the GSO earth station and its associated GSO satellite.

D2: Maximum pfd at the Earth's surface caused by transmissions from each non-GSO satellite in the constellation.

D3: Maximum number of co-frequency non-GSO satellites transmitting towards the same geographic region of the Earth, as well as an indication of the number of such satellites as a function of the percentage of time.

D4: Assumed off-axis gain of the GSO receive earth station towards the active non-GSO satellites. Recommendation ITU-R S.465 provides guidance in this respect.

D5: Assumed clear-sky receive system noise temperature (including receive antenna noise) of the GSO downlink. To err on the conservative side this need not include degradations caused to the overall link resulting from the uplink.

3.2 Uplink interference into GSO networks

U1: Minimum angular separation of the GSO orbit from the LoS between the transmitting non-GSO earth station and its associated non-GSO satellite.

U2: Maximum off-axis e.i.r.p. spectral density from the transmitting non-GSO earth station.

U3: Maximum number of co-frequency transmitting non-GSO earth stations within a geographic region of the Earth that is likely to be received by a single GSO satellite receive beam.

U4: Assumed maximum GSO satellite receive antenna gain.

U5: Assumed clear-sky receive system noise temperature of the GSO uplink. To err on the conservative side this need not include the overall link including downlink.

4 Calculation of downlink interference to the GSO networks

For the candidate non-GSO system considered here (USAKU-H2) the values of the key parameters necessary for this interference calculation, as required in section 3 above, are as follows:

D1: Minimum angular separation of the active transmitting non-GSO satellites from the LoS between the GSO earth station and its associated GSO satellite is never less than 40°.

D2: Maximum pfd at the Earth's surface caused by transmissions from each non-GSO satellite in the constellation is not greater than -165 dB(W/(m$^2 \cdot 4$ kHz)). This level is compatible with the use of gateway earth stations of no less than 5 m in diameter.

D3: Maximum number of co-frequency non-GSO satellites transmitting towards the same geographic region of the Earth is three[1]. This situation can occur for very short periods of time and only in certain geographic parts of the non-GSO service areas. The geographic areas concerned are those that have the ability to see the active service arcs of more than one of the non-GSO sub-constellations simultaneously. In these geographic situations only two non-GSO satellites are simultaneously visible for the vast majority of the time, but the number can rise to three at times of handover between the setting and the rising non-GSO active satellite (handover occurs typically for a duration of 10 s once every 4.8 h for each sub-constellation – we refer to this as short-term). In many geographic locations, only one active non-GSO satellite will be visible for the vast majority of the time, increasing to two at times of handover from the setting to the rising non-GSO active satellite. Based on this, the short-term levels of interference calculated here will occur typically for only 20 s (i.e. two sub-constellation handovers) every 4.8 h, which equates to about 0.1% of the time.

D4: Assumed off-axis gain of the GSO receive earth station towards active non-GSO satellites, as proposed in Recommendation ITU-R S.465, is as follows:

$$G = 32 - 25 \log(\theta) \qquad \text{for} \quad \theta_{min} \leq \theta < 48°$$

$$G = -10 \text{ dBi} \qquad \text{for} \quad 48° \leq \theta \leq 180°$$

where $\theta_{min} = 1°$ or $100\lambda/D$ (degrees), whichever is the greater.

D5: Assumed clear-sky receive system noise temperature (including receive antenna noise) of the GSO downlink is conservatively taken to be 80 K. This represents a fairly high performance downlink, and disregards any degradations caused to the overall link resulting from the uplink.

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[1] This is because the gateway earth station site (and therefore the gateway downlink beam coverage) for the sub-constellation operating in the southern hemisphere will be geographically separate from the gateway earth station site(s) and beam coverage for the northern hemisphere sub-constellations.

Using the above values for the key parameters the calculation of worst-case (short-term) downlink interference from the non-GSO system into any co-frequency GSO network is given in Table 1.

TABLE 1

Analysis of worst-case (short-term) downlink interference from USAKU-H2 system into a GSO earth station in the 3 700-4 200 MHz frequency band

Parameter	**Value**
Maximum pfd of USAKU-H2 satellite in 4 kHz (dB(W/($m^2 \cdot$ 4 kHz)))	–165
GSO orbit avoidance angle (degrees)	40
GSO receive earth station gain towards USAKU-H2 satellite (assuming 32 – 25 log(θ)) (dBi)	–8.0
Frequency (MHz)	4 000
Effective aperture of GSO receive earth station towards USAKU-H2 satellite (dBm^2)	–41.5
GSO receive earth station interfering signal power in 4 kHz (dB(W/4 kHz))	–206.5
GSO receive earth station interfering signal PSD (dB(W/Hz))	–242.6
Increase in interference due to three simultaneously visible USAKU-H2 satellites (dB)	4.8
GSO receive earth station interfering signal PSD (three simultaneously visible USAKU-H2 satellites) (dB(W/Hz))	–237.8
GSO receive earth station system noise temperature (K)	80
GSO receive earth station system noise PSD (dB(W/Hz))	–209.6
I_0/N_0 at GSO receive earth station input (short-term) (dB)	–28.2
$\Delta T/T$ degradation to GSO receive earth station (short-term) (%)	0.152

The analysis in Table 1 starts with the maximum downlink pfd of the USAKU-H2 satellite, as given in data item D2 above. Then based on the minimum 40° GSO orbit avoidance angle (data item D2), the gain of the GSO receive earth station antenna is calculated based on 32 – 25 log(θ) (data item D4) to be no greater than –8 dBi. This gain is converted to an effective aperture (dBm^2) using an appropriate receive frequency of 4 GHz. The use of the effective aperture then allows a simple calculation of the received interfering signal power, in a 4 kHz bandwidth, from a single USAKU-H2 satellite. After allowing for three simultaneously visible USAKU-H2 satellites (which is the worst-case, short-term value), and adjusting to a reference bandwidth of 1 Hz, this aggregate interfering signal power is compared to the inherent noise power of the GSO receiver (resulting from data item D5). Based on this, the interference-to-noise power density ratio (I_0/N_0) is calculated to be –28.2 dB, which is also expressed as an equivalent $\Delta T/T$ degradation to the GSO receive earth station performance of 0.152%. The worst-case long-term interference levels will be between two and three times less than this, with resulting I_0/N_0 values of between –31.2 dB and –33 dB, respectively, and ΔT/T degradation values of between 0.101% and 0.051%, respectively.

In previous sections of this Annex, it has been noted that the above analysis will overestimate the actual interference because the assumed three interfering satellites will not all be located at the minimum separation angle to a given GSO earth station location. As an example, consider the case where the GSO earth station is located in such a manner that the non-GSO satellite that is entering the active arc over North America is at the minimum separation angle of 40°. The angular separation for the non-GSO satellite that is at the end of this active arc will be about 60°. The third satellite is assumed to be located at the centre of the adjacent active arc. The angular separation for this satellite would be about 70°. The corresponding GSO earth station receive antenna gains toward the GSO satellite would be –10 dBi. The resultant $\Delta T/T$ degradation to the GSO receive earth station would be 0.11%.

5 Calculation of uplink interference to the GSO networks

For the candidate non-GSO system considered here (USAKU-H2) the values of the key parameters necessary for this interference calculation, as required in section 4 above, are as follows:

U1: Minimum angular separation of the GSO orbit from the LoS between the transmitting non-GSO earth station and its associated non-GSO satellite is never less than 40°.

U2: Maximum off-axis e.i.r.p. spectral density from the transmitting non-GSO earth station is computed from the maximum input PSD (–25.0 dB(W/4 kHz) in clear-sky and –21.8 dB(W/4 kHz) in rain fades due to the use of uplink power control) and the maximum off-axis gain of the non-GSO transmitting earth station in the direction of the GSO arc. The latter is conservatively assumed to be 36 – 25 log(θ).

U3: There is a direct relationship between the maximum number of co-frequency transmitting non-GSO earth stations within a geographic region of the Earth that are likely to be received by a single GSO satellite receive beam, and the assumed maximum GSO satellite receive gain (see data item U4). When the GSO satellite receive beamwidth is smaller than the non-GSO satellite receive beamwidth (as measured on the surface of the Earth), the maximum number is generally one. Only when the GSO satellite receive beamwidth is greater than the non-GSO satellite beamwidth will there be the possibility of multiple co-frequency emissions from the non-GSO transmitting uplinks. However, in this case the peak gain of the GSO satellite receive beam will be reduced, thereby resulting in less uplink sensitivity and lower levels on non-GSO interference per transmitting non-GSO earth station. Therefore the likely worst-case scenario is a high gain GSO receive spot beam, whose beamwidth (as measured on the surface of the Earth) is significantly less than the beamwidth of the non-GSO satellite receive beam (candidate system has a peak gain of 33 dBi at an operating altitude of 22 000 km). A 1.7° GSO receive spot beam, which is representative of future 6/4 GHz band multi-beam system designs, would be much smaller than the non-GSO receive beam and therefore would imply that only one co-frequency non-GSO transmitting earth station is to be considered for the uplink interference calculation. However, in order to address the handover situation, the analysis of short-term uplink interference will assume two such stations.

U4: See comments in data item U3 above in relation to the assumed maximum GSO satellite receive antenna gain. The conservative assumption in data item U3 above of a 1.7° receive spot beam would result in a GSO receive peak gain of approximately 40 dBi, and this value will be used in the interference calculation.

U5: Assumed clear-sky receive system noise temperature of the GSO uplink is conservatively taken to be 600 K. This represents a fairly high performance satellite receiver, and conservatively disregards any degradations caused to the overall link resulting from the downlink.

Using the above values for the key parameters the calculation of worst-case (short-term) uplink interference from the non-GSO system into any co-frequency GSO network is given in Table 2. This shows two columns for the calculation; one for the clear-sky condition and one for rain conditions where the uplink power control causes the maximum available increase in transmit power to overcome the rain fade. In fact the clear-sky calculation provides the most realistic assessment of the uplink interference situation because, for the rain fade condition, the interfering signal path can also be assumed to be faded by approximately the same amount as the wanted signal path in the USAKU-H2 system. The interference levels shown in the rain condition could only occur if the LoS from the USAKU-H2 transmitting earth station to the GSO satellite was unfaded while the LoS to the USAKU-H2 satellite was fully faded. Such a condition would be extremely rare, and if it ever existed at all would be of extremely short duration.

In Table 2 the calculation methodology is similar to that used for the downlink (see Table 1) and described above, using the data items U1 to U5 given above.

As noted above, the $\Delta T/T$ values produced by this analysis would only be received in the short-term (about 20 s every 8 h, or less than 0.1% of the time). The long-term I_0/N_0 values would be a minimum of 3 dB less since the non-GSO earth station would only be transmitting to one satellite. This 3 dB reduction would result in $\Delta T/T$ values of 0.418% for clear-sky and 0.873% for power control used in rain fade situations.

TABLE 2

Analysis of worst-case uplink interference from USAKU-H2 transmitting earth station into GSO satellite receiver in the 5 925-6 725 MHz frequency band

Parameter	**Value (clear sky)**	**Value (rain)**
Maximum PSD into USAKU-H2 earth station antenna in 4 kHz (dB(W/4 kHz))	–25.0	–21.8
GSO orbit avoidance angle (degrees)	40	40
USAKU-H2 Tx earth station gain towards GSO satellite (dBi)	–4.1	–4.1
USAKU-H2 Tx earth station e.i.r.p. spectral density towards GSO satellite in 4 kHz (dB(W/4 kHz))	–29.1	–25.9
pfd at the GSO satellite in 4 kHz (dB(W/(m^2 · 4 kHz)))	–191.2	–188.0
Frequency (MHz)	6 325	6 325
Assumed gain of GSO satellite Rx towards USAKU-H2 earth station (dBi)	40	40
Effective aperture of GSO satellite Rx towards USAKU-H2 earth station (dBm^2)	2.5	2.5
GSO satellite Rx interfering signal power in 4 kHz (dB(W/4 kHz))	–188.6	–185.4
GSO satellite Rx interfering signal PSD (one USAKU-H2 earth station) (dB(W/Hz))	–224.7	–221.5
GSO satellite Rx interfering signal PSD (two USAKU-H2 earth stations) (dB(W/Hz))	–221.7	–218.5
GSO satellite Rx system noise temperature (K)	600	600
GSO satellite Rx system noise PSD (dB(W/Hz))	–200.8	–200.8
I_0/N_0 at GSO satellite Rx input (short-term) (dB)	–20.8	–17.6
$\Delta T/T$ degradation to GSO satellite Rx (short-term) (%)	0.824	1.721

Tx: transmitting.

Rx: receiver.